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«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ
АКАДЕМИЯСЫ» РҚБ

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CALCULATION OF ENVIRONMENTAL AND ECONOMIC DAMAGE CAUSED BY CURRENT SYSTEMS OF SOLID WASTE MOVEMENT IN OIL PRODUCTION

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Abstract. In our country, oil and gas production among industrial sectors is considered to be at high risk from an environmental point of view. An increase in the amount of petroleum products leads to a decrease in the quality indicator of nature and a deterioration in the health of local people. The main types of environmental pollution in the field area and the reasons for their occurrence are identified. Hydrocarbons and impurities released into the atmosphere by the wind in the drilling of oil wells, in the production process and during accidents can pollute the environment and land, dangerous to humans, plants, as well as animals. The analysis of the currently existing methods for calculating harmfulness was carried out. The need to improve the waste management system, which includes organizational measures to control the formation of waste, control over their collection and storage, disposal and neutralization, is indicated. The impact of waste generated in the process of work on the environment will be minimized only if the principles of collection, storage, export, disposal and disposal of all types of waste are observed. The main factors for determining the amount of damage are the area, depth of contamination and concentration of petroleum products, which are determined on the basis of laboratory analyzes carried out on the basis of land survey materials and current regulatory and methodological documents. Reports on

the determination of environmental damage in case of emergency spills of oil and petroleum products, solid waste in production are given.

Keywords: oil and gas production, accidental spills, environmental damage, oil-contaminated soil, solid waste

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МҰНАЙ ӨНДІРУДЕГІ ҚАТТЫ ҚАЛДЫҚТАР ҚОЗҒАЛЫСЫНЫҢ ҚОЛДАНЫСТАҒЫ ЖҮЙЕЛЕРІНЕН БОЛАТЫН ЭКОЛОГО-ЭКОНОМИКАЛЫҚ ЗАЛАЛДЫ ЕСЕПТЕУ

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Аннотация. Өнеркәсіп салаларының арасында мұнай мен газ өндіру экологиялық тұрғыдан қауіпі жоғары екені белгілі. Мұнай өнімдері мөлшерінің артуы қоршаған ортаның сапалық көрсеткішінің төмендеуіне және жергілікті адамдардың денсаулығының нашарлауына әкеп соқтырады. Кен орны аймағында қоршаған ортаның ластануының негізгі себептері қарастырылды, келтірілетін зияндылықты есептеу әдістемелеріне талдау жүргізілді. Қалдықтардың пайда болуын бақылау, оларды жинақтау мен сақтауды, кәдеге жаратуды және залалсыздандыруды бақылауды қамтамасыз ететін қалдықтардын басқару жүйесін жетілдіру қажеттілігі көрсетілген. Зақымдану дәрежесін анықтаудың негізгі факторлары ауданы, ластану тереңдігі және зертханалық зерттеулер негізінде анықталатын мұнай өнімдерінің концентрациясы негізінде жүзеге асырылады. Мұнайдың және мұнай өнімдерінің апаттық жағдайда төгілуінің, өндіру кезінде пайда болатын техногендік қатты қалдықтардың экологиялық зиянын анықтау есептеулері келтірілген.

Түйін сөздер: мұнай-газ өндіру, авариялық төгілулер, экологиялық залал, мұнаймен ластанған топырақ, қатты қалдықтар

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РАСЧЕТ ЭКОЛОГО-ЭКОНОМИЧЕСКОГО УЩЕРБА ОТ СУЩЕСТВУЮЩИХ СИСТЕМ ДВИЖЕНИЯ ТВЕРДЫХ ОТХОДОВ ПРИ ДОБЫЧЕ НЕФТИ

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Аннотация. В нашей стране добыча нефти и газа среди промышленных секторов считается подверженной высокому риску с экологической точки зрения. Увеличение количества нефтепродуктов приводит к снижению показателя качества природы и ухудшению здоровья местных жителей. Выявлены основные виды загрязнения окружающей среды в районе месторождения и причины их возникновения. Углеводороды и примеси, выбрасываемые в атмосферу ветром при бурении нефтяных скважин, в процессе добычи и во время аварий, могут загрязнять окружающую среду и землю, опасны для людей, растений, а также животных. Был проведен анализ существующих в настоящее время методов расчета вредоносности. Указывается на необходимость совершенствования системы управления отходами, которая включает организационные меры по контролю за образованием отходов, контроль за их сбором и хранением, утилизацией и обезвреживанием. Воздействие отходов, образующихся в процессе работы, на окружающую среду будет сведено к минимуму только при соблюдении принципов сбора, хранения, экспорта, утилизации и обезвреживания всех видов отходов. Основными факторами для определения размера ущерба являются площадь, глубина загрязнения и концентрация нефтепродуктов, которые определяются на основании лабораторных анализов, проведенных на основании материалов землеустройства и действующих нормативно-методических документов. Приведены расчеты по выявлению экологического ущерба твердых отходов при аварийных разливах нефти и нефтепродуктов, добыче.

Ключевые слова: нефтегазодобыча, аварийные разливы, экологический

ущерб, нефтезагрязненная почва, твердые отходы

Introduction

Oil and gas production is considered one of the most environmentally dangerous industries. It is dispersed into the atmosphere during the drilling of wells with oil products, the production process and during an accident, and hydrocarbons and various substances pollute the environment, land, and become dangerous to the population, plants, and animals. Environmental safety is a very important condition for the development of society. Environmental safety is the basis for the preservation of natural systems and the stability of the quality of the environment. However, many nature users do not pay much attention to environmental issues. Therefore, an increase in the amount of oil products leads to a decrease in the quality of nature and the deterioration of the health of local people. At the present time, the methods of calculating harmfulness to the environment have a number of shortcomings, so when calculating the amount of ecological damage caused by oil spilled on the surface of the air, land, and water resources, there are disputes between enterprises on the basis of court. The amount of pollution with chemical substances is determined based on the calculation of the rules of payment of oil products, soil pollution with groundwater. These rules provide for the types of compensation for placing oil objects without permission. But it can be seen that many factors are left out of this rule.

Research materials and methods

It can be said that the existing methodology for determining the impact on the environment has some shortcomings, as a result of which legal disputes arise between controlling and production organizations when compensating for damage caused by pollution of the atmosphere, land and water resources from accidental spills of oil and petroleum products. When determining the amount of damage caused by chemical pollution, it establishes rules for calculating compensation for damage caused by soil and groundwater pollution, including from the placement of unauthorized oil reservoirs. In this regard, it is necessary to develop a methodology that provides an objective concept for calculating the amount of harm caused by pollution of the atmosphere, land and water resources during the use of harmful substances in the processes of production, transportation and processing of oil and oil products. The methodology for calculating economic damage from pollution of the natural environment (atmosphere, soil, water) should take into account a complex of values and determine the amount of damage caused to certain types of recipients within the pollution zone. At the same time, the damage caused by environmental pollution should be understood as the loss of labor costs, material and financial resources due to the elimination of the consequences of pollution in the economic sector, as well as the deterioration of social and hygienic conditions. The amount of damage caused by the pollution of the land with oil products, including the installation of unauthorized reservoirs, is collected from enterprises, institutions, organizations and other legal entities, including joint ventures with the participation of foreign legal entities and citizens, regardless of their organizational and legal forms and forms of ownership. For the pollution of the land with oil products, aquifers, including the placement of unsanctioned reservoirs, fines for compensation of environmental damage are made and proposed to guilty organizations, environmental enterprises, nature protection organizations by authorized bodies and responsible officials. Organizations guilty of polluting the natural environment are also obliged to take necessary measures to eliminate the consequences of pollution.

To determine the extent of damage, the area, depth and concentration of petroleum

products are determined based on laboratory analyzes carried out according to land management data and current regulatory and methodological documents. Each stage of the flow of oil waste is accompanied by the release of pollutants into the environment. The qualitative and quantitative composition of emissions differs in stages and is associated with the technological methods used in working with oil waste. To analyze the existing scheme for working with solid oil waste, it is necessary to assess the level of damage caused by pollutants to natural components in the process of working with oil waste. The assessment of environmental and economic damage was carried out according to (Rozhkova et al., 2021: 151–158; Bektenov et al., 2016: 95–101; Kireev et al., 1998: 132–138; Kuanbayeva et al., 2024: 1640–1647). Total environmental damage to the natural environment (D) means an assessment in monetary terms of negative consequences caused by anthropogenic impact of oil waste. Defined as the sum of damage caused by pollution of waste disposal with all its components: soil and land resources (D_s), soil with chemicals (D_{ch}), atmospheric air (D_a), water resources. D_w).

$$D = D_s + D_{ch} + D_a + D_w \quad (1)$$

Hazard class 1 stabilization of the ecological system based on oil waste recycling the magnitude of the environmental damage caused in advance to the natural environment as a result of waste disposal is determined by the following formula:

$$D_s = D_{sl} \cdot \Sigma i V_i \cdot \rho K_{1i} \quad \text{tenge} \quad (2)$$

here: V_i - the amount of placement of waste of hazard class i of the object, t; K_{1i} - coefficient taking into account the hazard class of the chemical substance of waste i ($K_{1i} = 2$ for oil waste of hazard class 3); D_{sl} – index of damage to the natural environment of region i as a result of disposal of 1 ton of dangerous IV class waste, tenge/t (For Kyzylorda region D_{sl} = 692 tenge/t). The amount of damage caused to the earth by chemical contamination (D_{ch}), tenge, is determined by the following formula:

$$D_{ch} = D_{ch\,s} \cdot \Sigma j S_j \cdot K_{1i} \cdot K_{sj} \quad (3)$$

here: $D_{ch\,s}$ - environmental damage caused by contamination of the earth with a hazardous chemical substance during the reporting period (for Kyzylorda region $D_{ch\,s}$ - 122,0 thousands tenge/ha); S_j - land area of j type contaminated with chemical substance i hazard class during the reporting period, ha; K_{1i} - soil pollutant i is a coefficient that takes into account the hazard class of the chemical substance (for oil sludges of hazard class 3 is K_{1i} = 2); K_{sj} - coefficient of natural and economic value of j-type soil and lands (for industrially undeveloped lands K_{sj} = 1,3).

The amount of damage caused by emissions of harmful substances into the atmosphere (D_a), tenge, is determined by the following formula:

$$D_a = D_{a\,s} \cdot \Sigma i M_{ia} \cdot K_{eia} \cdot K_{ae} \quad (4)$$

here: $D_{a\,s}$ - regional indicator of specific damage to the atmospheric air caused by the emissions of the unit mass of pollutants at the end of the reporting time period, tenge/t (for the Kyzylorda economic district $D_{a\,s}$ = 34,4); M_{ia} - actual mass of a pollutant or a group of substances with the same coefficient of relative environmental and economic danger during the reporting period, t; K_{eia} - and the relative environmental and economic hazard coefficient of the pollutant (for hydrocarbons K_{cia} = 0,7); K_{ae2} - regional coefficient of ecological importance of the territory's ecological climate and atmospheric air condition (for the Kyzylorda economic district K_{ae2} = 1,7). According to the methodological instructions for calculating the total emissions of harmful substances into the atmosphere for oil refining and petrochemical enterprises (Tanzharikov et al., 2021: 99–108), the amount of emissions of harmful substances from ponds and sludge accumulators can be calculated according to the equation.

The amount of environmental damage caused by pollution of water resources (Z_{su}), tenge, is determined by the following formula:

$$D_w = \Sigma j\,(D_{ws} \cdot \Sigma_i M_{iw} \cdot K_{eiw}) \cdot K_{we} \quad (5)$$

here: D_{ws} - indicator of the relative damage to water resources caused by the unit of mass of pollutants at the end of the reporting period for water object j in the region under review, tenge/contract, t (for Kyzylorda region D_{ws} = 25264 tenge/t); M_{iw} - the actual mass of a state pollutant or a group of substances with the same coefficient of environmental and economic danger during the reporting period, t; K_{eiw} - relative environmental and economic hazard coefficients for a pollutant or a group of substances (for sulfate and chloride K_{eiw} = 0,05, for oil products K_{eiw} = 20); K_{we} - coefficient of the ecological condition and ecological importance of water bodies in the main river basins (for the Syrdaria River is K_{we} = 1,09-1,16). As an example for the calculation, the indicators of the accident that occurred in the main oil pipeline Kumkol and Zhosaly were used (Figure 1–2). In 2004, it became known that a large amount of oil was spilled on the ground due to an accident in the trunk pipeline, which occurred on the 29–30 km of the highway, polluting a number of land areas and causing some damage to the ecological condition of nature. Therefore, the amount of damage caused by the accident to nature was calculated. The territories damaged by oil products are divided into sections, and the depth of seepage into the ground in each section is given below: section 1–80 cm, section 2–80 cm, section 3–80 cm, section 4–80 cm, section 5–150 cm.

Figure 1 - View of the oil spill area

Figure 2 - An oil-contaminated area of a main oil pipeline

During the research, it was found that the area of the land damaged by oil products, penetrated to a depth of 80 cm, is 13490 m^2, and the area of the land damaged to a depth of 150 cm is equal to 260 m^2. These areas were divided into several sections, and samples were taken from those areas to determine the amount of oil products that entered the soil and

make an examination. The results of the conducted research and the amount of oil products that entered the soil are given in Table 1.

Table 1 - Results of conducted studies

№	Location of sampling	Sampled depth, m	Possible reference factor, mg/kg	Amount of oil in the soil, mg/kg
1	Part 1. Upper floor	0-0,2	1000	65500
2	Part 1. Middle layer	0,5	1000	25000
3	Part 1. Lower floor	0,8	1000	10000
4	Part 2. Upper floor	0-0,2	1000	59020
5	Part 2. Middle layer	0,5	1000	56020
6	Part 3. Upper floor	0-0,5	1000	51700
7	Part 3. Middle layer	0,5	1000	22800
8	Part 3. Lower floor	0,8	1000	9000
9	Section 4. Upper floor	0-0,2	1000	60000
10	Section 4. Middle layer	0,5	1000	51700
11	Section 4. Lower floor	0,8	1000	22800
12	Section 5. Middle layer	0,5	1000	25020

As we can see from the table, it can be seen that the considered areas are highly polluted by oil products. It can be seen that it is 9-65,5 times more than the standard coefficient. Table 2 lists the values necessary for calculating the environmental damage measure (Tanzharikov et al., 2020: 332; Gilazhov, 2013: 338; Tanzharikov et al., 2018: 4360–4364; Abilbek et al., 2019: 4270–4276; Tusupkaliev et al., 2021: 251–258; Guidance document GD-17-89, 1990: 25).

Table 2 - Necessary values for calculating the environmental damage measure

Values name	Value	Source of values
1	2	3
D_{sl} – payment standard for placement of 1 t of harmful waste on the ground	298,53	№232, 06.12.2005 Decision of regional council
K_{1i} - soil pollutant i is a coefficient that takes into account the hazard class of a chemical substance	2	Methodology for calculating the harm caused by pollution of oil products to air, land and water sources
K_{lj} – j-type soil and coefficient of natural and economic importance of lands (K_{lj} = 1.3 for undeveloped industrial lands)	1,3	Provisional methodology for calculating damage to air, land and water resources polluted by oil products
K_{dia} - the relative environmental and economic hazard coefficient i of the pollutant (for hydrocarbons K_{dia} = 0,7)	0,7	Provisional methodology for calculating damage to air, land and water resources polluted by oil products
K_{lia} – soil damage factor		
K_{ac2} - regional coefficient of ecological importance of the territory's ecological climate and atmospheric air condition (for the Kyzylorda economic district K_{ac2} = 1,7)	1,7	Provisional methodology for calculating damage to air, land and water resources polluted by oil products

K_{ae} – indicators showing the atmospheric conditions in the studied area		Provisional methodology for calculating damage to air, land and water resources polluted by oil products
ρ – density of oiled soil	1,37	
h_1, h_2, h_3 – depth of oil penetration into the soil	130 cm 130 cm 130 cm	14.05.2004 №104 act - according to instructions
S_1, S_2, S_3 – the area of contaminated land with oil products	5460 m^2 5600 m^2 11340 m^2	14.05.2004 №104 act - according to instructions
MM is the amount of oil in oiled soil	672,9 t	Determined by calculating the value obtained by measuring contaminated soil (chemical examination results)

We determine the amount of damage caused to the territory contaminated by oil products as follows:

$$D = D_s + D_{ch} + D_a + D_w$$

Here:

D_s – damage caused to the location of oil waste.

D_{ch} – damage of chemicals to earth resources.

D_a – harm of chemicals to atmospheric air.

D_w – amount of damage caused by chemicals to water sources.

$$D_s = D_{s\,l} \cdot \Sigma i V_i \cdot \rho\, K_{1i} \text{ tenge}$$

Here: $D_{s\,l}$ – the amount of damage caused to the location of 1 t of oil residue, tenge. $D_{s\,l}$ – 298,53 tenge/t. (№232, 06.12.2005 Approved by the council of Kyzylorda region).

V_i – amount of oil spread on the ground, t.

$$V_i = (S_1 \cdot h_1 + S_2 \cdot h_2 + S_3 \cdot h_3)$$

S_1, S_2, S_3 – the area of contaminated land with oil products.

h_1, h_2, h_3 – depth of oil penetration into the soil.

ρ – density of oiled soil.

K_{1i2} – coefficient of calculation of danger due to ecology of the land contaminated with oil product residues.

$$D_s = 298{,}53 \text{ t/tenge} \cdot 39894{,}4 \text{ t} \cdot 1{,}37 \cdot 2 = 23819350{,}464 \text{ tenge}$$

$$V_i = (1{,}3 \text{ m} \cdot 5460 \text{ m}^2 + 1{,}3 \text{ m} \cdot 5600 \text{ m}^2 + 1{,}3 \text{ m} \cdot 11340 \text{ m}^2) = (7098+7280+14742) = 39894{,}4 \text{ tenge}$$

$$D_{ch} = D_{ch\,l} \cdot \Sigma j S_j \cdot K_{1i} \cdot K_{sj}$$

$D_{ch\,l}$ – amount of damage caused to earth resources by chemicals, tenge.

According to (Rozhkova et al., 2021: 151–158), is 110 000 tenge/ha.

$D_{ch\,l}$ = 110000 · 2,24 ha = 246400 tenge/ha.
$D_{ch\,l}$ – 246400 tenge/ha.
S_j – areas of lands damaged by oil waste, ha.

$$S_j = S_1 + S_2 + S_3$$

$$S_j = 5460\ m^2 + 5600\ m^2 + 11340\ m^2 = 22400\ m^2 = 2,24\ ha$$

S_j – 2,24 ha.
K_{1i} = 2.
K_{lj} – coefficient of need for economy and nature.
K_{lj} = 1,3.

$$D_s = 246400\ tenge/ha \cdot 2,24\ ha \cdot 2 \cdot 1,3 = 1435033,6\ tenge.$$

$$D_a = D_{as} \cdot \Sigma i M_{ia} \cdot K_{eia} \cdot K_{ae}$$

D_a – harmful effects of chemicals on the atmosphere.

$$D_{as} = 385\ tenge/t\ (Rozhkova\ et\ al., 2021: 151–158)$$

$$D_a = 385 \cdot 39894,4 \cdot 0,7 \cdot 1,7 = 18277619,36\ tenge$$

M_{ia} – amount of oil residue in the studied area, etc.
M_{ia} – 39894,4 tenge.
K_{eia} – coefficient indicating damage to the ground.
K_{eia} – 0,7.
K_{ae} – coefficient of environmental indicator of the atmosphere in the studied area.
K_{ae} – 1,7.

$$D_w = \Sigma j \cdot (D_{ws} \cdot \Sigma i M_{iw} \cdot K_{eiw}) \cdot K_{we}$$

Here: D_{ws} – amount of damage caused to water resources by chemicals, tenge.

$$D_{ws} = 8264\ tenge/t\ (Rozhkova\ et\ al., 2021: 151–158)$$

M_{iw} – mass of oil residue in the studied area, t. K_{eiw} – coefficient indicating damage to water resources (sulfate and chloride K_{eiw} = 0,05, for oil products K_{eiw} = 20); K_{we} – coefficient considering the environmental condition of objects near water resources in the studied area (K_{we} = 1,09 - 1,16). In the example under consideration, there is no water source near the accident D_{ws} = 0.

There fore:

D = 23819350,464 tg + 1435033,6 tg + 18277619,36 tg = 43532003,424 tg.

Results and discussion. Due to the dangerous environmental impact, harm to the environment and any living object, as well as to human health, is determined by the deterioration of parameters characterizing the state of environmental components, as well as the vital activity of the human body. In general, there may not be a deterioration, or it may occur during a harmful effect, or at any time after its end.

Monetary assessment of environmental damage includes an assessment of environmental damage losses in this regard, as well as costs and losses associated with the fact of the environmental harmful effects, that is, related to the fact of violations of environmental safety conditions. These last costs and losses are associated with additional control measures, monitoring with the need to take preventive measures to reduce the negative impact in the future.

Conclusions. An improved calculation of the amount of environmental damage for damage caused by oil and oil products spills and land resources as a result of the accident was proposed. The calculation method includes a correction factor, which reflects the volume of spilled oil based on the results of sample samples and chemical analyzes that determine the presence of oil in the composition.

According to the advanced method, an additional indicator was introduced into the formula for calculating the amount of environmental damage, which calculates the oil content in fuel oil. Taking into account the amount of spilled oil, the area of damaged areas, and the depth of oil absorption into the soil, it is possible to establish the amount of environmental damage caused to land resources.

As the analyzes show, for an objective comprehensive assessment of the environmental impact, it is necessary to classify the magnitude of the impact on each of its components separately, using three main indicators. Only in compliance with the requirements of technical and environmental safety standards, there will be no significant changes in the components of the environment during various activities.

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